Appendices

Appendices

Appendix A

Injuries

Appendix A—Injuries

The following information regarding injuries sustained by members of CDF Helitack Crew 404 was obtained from injury reports (CDF Form 3067), return to work forms (CDF Form 200), followup reports and the pathology/autopsy report.

CDF Fire Captain Jonah Winger:

Fire Captain Winger was medically evaluated at Sonora Regional Medical Center. He received several small (spots) second degree burns on his face. Fire Captain Winger was treated and released to full duty on September 12, 2004.

CDF FF-I Joshua Agustin:

Firefighter Agustin was medically evaluated at Sonora Regional Medical Center. He received no injuries and was released to full duty on September 12, 2004.

CDF FF-I Jon Andahl:

Firefighter Andahl was medically evaluated at Sonora Regional Medical Center. He received a small second degree burn on his left wrist (approximate size 1" x 2") and a small second degree burn on his nose ("dime" size). Initial emergency room x-rays indicated a possible fracture to his left ankle; however, additional x-rays indicated Firefighter Andahl's left ankle was not fractured. He was treated and released to modified work status September 12. Firefighter Andahl returned to full duty on October 6, 2004.

CDF FF-I Jeff Boatman:

Firefighter Boatman was medically evaluated at Sonora Regional Medical Center. He received no injuries and was released to full duty on September 12, 2004.

CDF FF-I Thomas Fraser:

Firefighter Fraser was medically evaluated at Sonora Regional Medical Center. He received no injuries and was released to full duty on September 12, 2004.

CDF FF-I Shane Neveau:

Firefighter Neveau was medically evaluated at Doctor's Medical Center in Modesto. He was admitted for smoke inhalation and received respiratory therapy and was released on September 13, 2004. There were initial concerns he received first and second degree burns to his backside; however, medical evaluation revealed no burn injuries. Firefighter Neveau was released to modified work status on September 14 and returned to full duty on September 20, 2004.

CDF FF-I Eva Schicke:

Firefighter Schicke received fatal injuries at the accident site. The pathology/autopsy report stated the following:

Cause of Death:

Inhalation of products of combustion.

Time frame: seconds.

Autopsy Findings:

1. Inhalation of products of combustion; desquamation and thermal change of mucosa of airway.
2. Inhalation of material consistent with soil. This material was non-occlusive in the airway.
3. Charring of the entire body, postmortem.
4. Postmortem fracture of the right tibia/fibula.
5. Postmortem fractures of the posterior left ribs.
6. Blood carboxyhemoglobin (COHb) saturation = 5%. (Toxic concentration = 15 to 50%, fatal concentration = greater than 50%.)

Additionally: Remnants of a tubular nylon/Velcro knee brace were found on the left knee. Firefighter Schicke experienced two reportable injuries to her left knee (Fire Season 2002, Fire Season 2003). Relative to the knee injuries, Firefighter Schicke received return to work orders (CDF Form 200) with no restrictions; the last Form 200 was dated May 1, 2004. Firefighter Schicke did not demonstrate, nor report, any physical performance limitations during her assignment between May 1 and September 12, 2004.

Appendix B

Personal Protective Equipment (PPE)

Appendix B—Personal Protective Equipment (PPE)

The Personal Protective Equipment (PPE) issued to firefighters of CDF Helitack Crew 404 consisted of the following items:

- Helmet with chin strap
- Goggles
- Nomex shroud
- Nomex shirt
- Nomex pants
- Gloves
- Chainsaw chaps
- Fire shelter

The PPE assigned to Fire Captain Winger and firefighters Agustin, Andahl, Boatman, Fraser and Neveau was inspected and photographed by investigation team member Battalion Chief Rob Van Wormer. With the exception of Firefighter Schicke's PPE, none of the PPE issued to Crew 404 was damaged or failed to function during the burnover. The burnover and subsequent residual burning destroyed Firefighter Schicke's PPE.

Additional items and supplies carried by the firefighters included the following items:

- Web gear
- Canteens
- Headlamp
- Fire tool
- Fusees
- Chainsaw with accessories (as assigned)
- First aid kit
- HT radio (as assigned)
- Personal items

The average weight of the PPE with web gear and complement was 40-45 pounds. Additional details regarding PPE are found in the supporting data section.

Appendix C

Experience, Training, Qualifications

Appendix C—Experience, Training and Qualifications

The following is a summary of experience, training and qualifications for the personnel involved in the burnover of CDF Helitack Crew 404 listed below. Individual training records may be found in the documentation section.

Title/Name	Experience	Qualifications/Training
Battalion Chief Dan Ward CDF	Air Attack 9 yrs. 3 mo. Forester 10 yrs. 6 mo. Captain 8 yrs. 8 mo. Engineer 1 yr. 10 mo.	Air Attack MGT I-271 Helibase MGR I-357 Air Support I-470 Air Ops I-420 Command and General Staff I-300 Intermediate ICS Type 1 Helicopter MGR I-430 Operations Section Chief Incident Management I, II & III S-290 Intermediate Fire Behavior S-490 Advanced Fire Behavior
Forestry Pilot Tom Eggleston CDF	Perm. 5 yrs LT 10 seasons	Air Attack MGT Type 1 Helicopter MGR I-300 Intermediate ICS CDF Short Haul Pilot and Rescuer
Fire Captain Frank Podesta CDF	Captain 11 yrs. Engineer 6 yrs. Hotshot Captain USFS, 10 yrs.	Air Attack MGT I-271 Helibase Manager I-374 Helicopter Coordinator I-375 Air Support Supervisor I-378 Air Attack Supervisor Military Helicopter Manager Type 1 Helicopter Manager CDF Short Haul Basic Crew Captain S-212 Wildfire Power Saw I-300 Intermediate ICS Incident Management 2 I-224 Field Observer Fire Management 2
Fire Captain Jonah Winger CDF	Helitack Captain 8 weeks Captain 2 yrs. 2 mo. Engineer Paramedic 2 yrs. FF/Para. 2.5 yrs. Pioneer Vol/FF 2.5 yrs. Pioneer	Fire Crew Captain Module 1 Fire Crew Captain Module 2 S-212 Wildfire Power Saw Incident Management I & II I-200 Basic ICS I-300 Intermediate ICS Driver Operator Module SFM Fire Officer S-290 Intermediate Fire Behavior

Firefighter Eva Schicke CDF	6 months Helitack 4 seasons Engine	CDF Firefighter I Basic CDF Advanced FFI CDF Basic Helitack S-212 Wildfire Power Saw
Firefighter John Andahl CDF	5 months Helitack 3 seasons Engine 1 season tanker base	CDF Firefighter I Basic I-100 Introduction to ICS S-212 Wildfire Power Saw
Firefighter Josh Agustin CDF	6 seasons Helitack 4 seasons Engine	CDF Firefighter I Basic CDF Basic Helitack CDF Advanced FFI I-100 Introduction to ICS I-272 Helispot Manager
Firefighter T.J. Fraser CDF	2 seasons Helitack 4 seasons Engine	CDF Firefighter I Basic Wildland Firefighter Survival S-190 Introduction to Fire Behavior S-212 Wildfire Power Saw
Firefighter Jeff Boatman CDF	2 seasons Helitack CDF 1 season Engine CDF 2 seasons Hot Shot USFS 1 season Crew USFS	CDF Firefighter I Basic S-212 Wildfire Power Saw S-234 Ignition Operations S-270 Basic Air Operations S-205 Fire Operations in Urban Interface S-200 Initial Attack Incident Commander S-230 Crew Boss Single Resource I-200 Basic ICS I-300 Intermediate ICS S-211 Portable Pumps and Water Use
Firefighter Shane Neveau CDF	1 season Helitack 3 seasons Engine	CDF Firefighter I Basic CDF Advanced FFI I-100 Introduction to ICS S-190 Introduction to Fire Behavior S-212 Wildfire Power Saw

Division Chief Allen Johnson USFS	DFMO 1 yr. 6 mo. Asst. DFMO 15 yrs. 6 mo. Hotshot Fore/Supt. 3 yr. 2 mo. Captain 4 yrs. 10 mo. Fire Prev. Tech 1 yr. 4 mo. Engineer 1 yr. 6 mo. Firefighter 2 yrs.	Incident Commander Type 2 Operations Section Chief Type 2 Logs. Section Chief Type 2 Resource Unit Leader Staging Area Manager Firefighter 1 & 2 I-300 Intermediate ICS I-339 Division/Group Supervisor I-420 Incident Command & General Staff Interagency Aviation MGT & Safety S-390 Intro to Advanced Fire Behavior S-490 Advanced Fire Behavior Calcs
Fire Captain Tammy Mount USFS	Captain 7 yrs. Engineer 5 yrs. 11 mo. Firefighter 1 yr. 7 mo.	Crew Boss Engine Boss Helicopter Crew Member Strike Team Leader Engines Strike Team Leader Crews Incident Commander Type 4 Safety Officer Type 3 Task Force Leader Firefighter 1 & 2 I-300 Intermediate ICS S-390 Intro to Advance Fire Behavior

Appendix D

Fire Environment

Report approved by Board of Review May 11, 2005.

Appendix D—Fire Environment

This section is a summary of the fire environment on the afternoon of September 12, 2004. It discusses the topography, condition of the vegetation or fuels in the area and the weather related factors that influenced the fire behavior.

Topography

The Tuolumne River is a major drainage in the Sierra Nevada range and flows westward from the crest toward the Central Valley. The canyon in the area of the accident site is topographically complex with steep, rugged, broken terrain. The canyon is 2,000' deep at the accident site with steep canyon sides and numerous intermittent and perennial tributary streams flowing into the Tuolumne River. The accident site was located at the bottom of the Tuolumne River Canyon at 1450 feet elevation. The slope was 90 percent at the accident site.

Photo D-1: Tuolumne River Canyon looking northeast. Tuolumne fire is located in the center of photo. Accident site is obscured by ridge in foreground.

Photo D-2: Tuolumne River Canyon looking downriver to the west. Photo was taken approximately 150' above accident site. Accident site is not visible in this photo.

Fuels

Vegetation in the general area is intermingled pine-oak woodland and chaparral brush. Tree species in the accident site area were primarily canyon live oak *(Quercus chrysolepis)* with an occasional gray pine *(Pinus sabiniana)* and California black oak *(Quercus kelloggii)*. Shrub species in the accident site area was primarily toyon *(Heteromeles arbutifolia)* and interior live oak *(Quercus wislizeni)*. Other brush species in the general area included manzanita *(Arctostaphylos spp.)*, deerbrush, blueblossom *(Ceanothus spp.)*, California buckeye *(Aesculus californica)* and chamise *(Adenostoma fasiculatum)*. The surface fuel layer consisted of oak leaf and pine needle litter and sparse, short, discontinuous cured annual grasses less than 12 inches in height.

Fire history records indicate the fuels last burned in 1987 as part of either the Hamm 87 or Clavey 87 Complex. On-site evidence near the accident site indicates that the fire was of low to moderate intensity, as many larger diameter trees survived the fire.

The vertical continuity of the fuel in the accident site area is best described as a three-layered fuel bed. The surface fuel layer of sparse short grass, oak leaf and pine needle litter provided a light, flashy fuel bed. One-hour fine dead fuel moisture was calculated at four to five percent for exposed fuels and six to seven percent for shaded fuels. The intermediate fuel layer consisted of brush, predominately toyon and young live oaks that ranged in height from 4 to 10 feet. The upper fuels layer consisted of the larger diameter oak and pine trees that ranged in height from approximately 30 to 100 feet.

While there was natural variability in the three-layered fuel bed, it was significant in that it provided ladder fuels for a surface fire to spread to higher levels dependent upon site-specific vertical continuity, surface fire intensity and flame lengths. Critically low, live fuel moistures allowed the fire to transition from the surface fuels to the aerial brush fuels very quickly.

The following two photos show fuels west of the accident site on a similar aspect and elevation. The photos depict fuels similar to those in which the fire was burning in the area below the road. At the accident site there was a more natural opening with less brush present.

Photo D-3. Surface fuels similar to those in which the fire was burning.

Photo D-4. Unburned fuels just west of final fireline below road. Final right flank fireline is in the foreground. This was approximately 100 feet south of accident site.

Live Fuel Moisture

The amount of live fuel moisture determines how readily brush will burn and if it will contribute significantly to fire spread and intensity. As the moisture in the living fuel declines throughout the growing season, more of the living fuel can become involved in a fire and the probability of rapid spreading high intensity fires increases. Experience has indicated that, in general, sustained, fast-spreading and high-intensity fires in chaparral are infrequent until the live fuel moisture has declined to about 60 percent in chamise and 80 percent in manzanita. These moisture levels are often designated as the "critical" fuel moistures for these fuels.

Live fuel moistures are sampled on a routine basis by both the CDF Tuolumne-Calaveras Unit and the Stanislaus National Forest to track seasonal fuel moisture trends in chamise and manzanita. Table 1 displays the most recent live fuel moisture samples taken by the Tuolumne-Calaveras Unit. The sampling location is 20888 Lyons-Bald Mtn. Road, Sonora, CA in Tuolumne County. The elevation is 2500 feet, south aspect, 30 percent slope.

Table 1: Recent Live Fuel Moistures

Date	Chamise (average)	Manzanita (average)
4/8/2004	119%	117%
4/22/2004	114%	122%
5/12/2004	104%	107%
6/2/2004	87%	104%
7/6/2004	66%	83%
7/28/2004	58%	77%
8/31/2004	54%	55%

Note: Bold numbers indicate critical fuel moisture values.

Table 2 displays on-site fuel moisture samples taken after the incident on September 17, 2004. Samples were taken on a similar aspect and elevation just south of the final perimeter of the Tuolumne fire below the road.

Table 2: On-site Fuel Moisture

Date	Chamise (average)	Manzanita (average)	Toyon (average)
9/17/2004	61%	71%	74%

Note: Bold numbers indicate critical fuel moisture values. Chamise is considered as critical as it was only 1 percent above threshold value.

While toyon is not routinely sampled and critical fuel moisture thresholds have not been established for the species, it could be expected to follow similar patterns to indicate flammability. One sample of underburned, scorched toyon brush was taken 34 feet southwest of the body retrieval site, on a similar aspect and elevation (See photo 5). The moisture content was four percent. It is unknown what the moisture content was immediately after the flaming front passed through. However, the low moisture content at the time of sampling indicates that almost all the moisture in the plant had been driven off by the surface fire and was on the threshold of igniting and sustaining combustion. Any minor increase in surface fire intensity or flame length could be expected to ignite these aerial fuels.

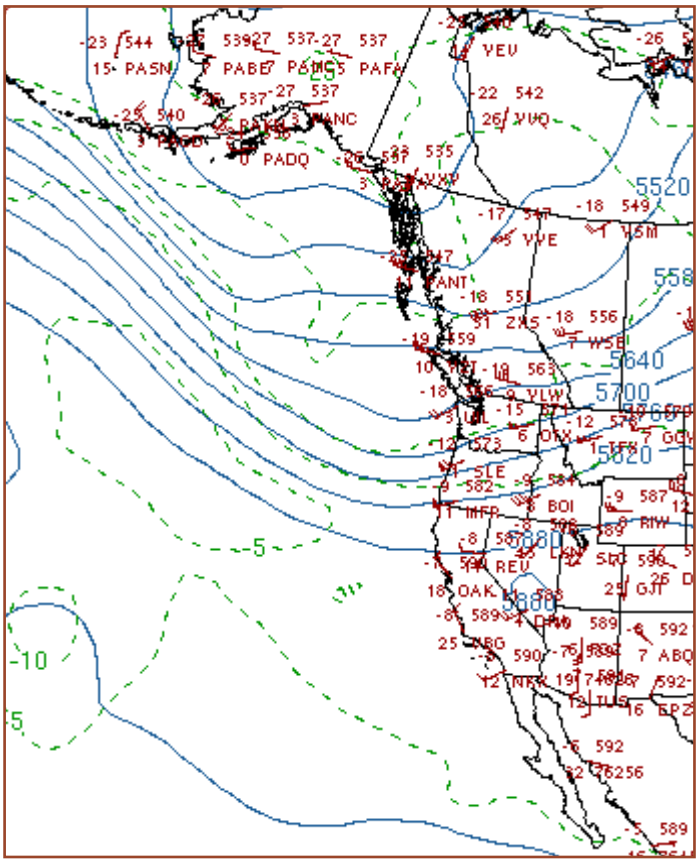
Photo D-5. Underburned toyon brush.

Weather

Synoptic summary:

A fairly strong ridge of high pressure had been over the area for several days prior. Beginning the day before the entrapment (9/11/04), the southern edge of a low pressure trough began to move into Northern California (Figure 2).

Figure 2: 500 mb Chart 9/11/04 1700 PDT



This trough continued moving inland and further south, passing over the fire area the day of the entrapment (9/12/04 – Figures 3 and 4). There were no severe fire weather patterns over the area (e.g. dry cold front passage, thunderstorms, etc.). The weather changes from the trough passage that occurred, compared to previous days, were: noticeably cooler temperatures, somewhat higher humidity and a slight increase in wind speeds.

Figure 3: 500 mb Chart 9/12/04 1100 PDT

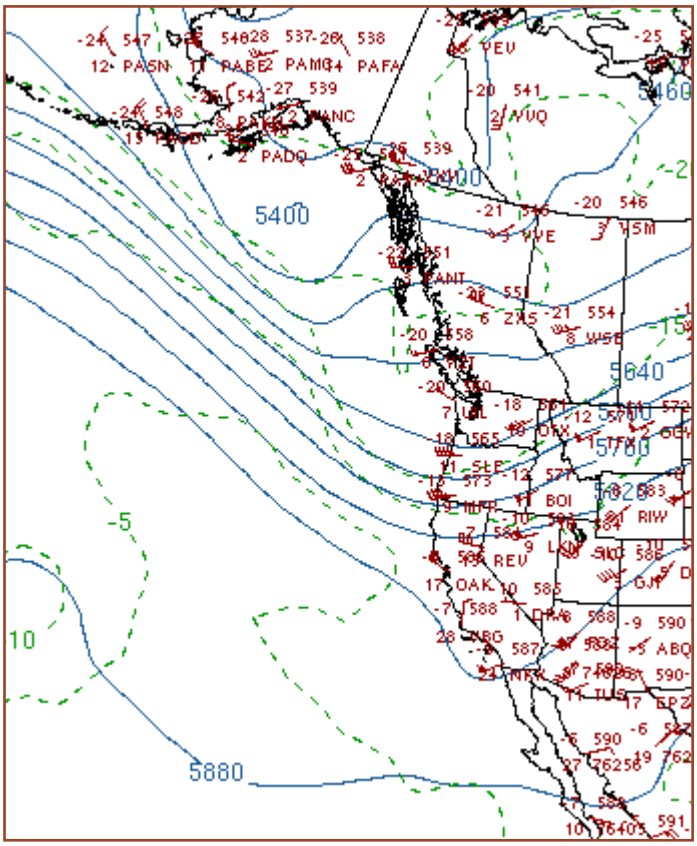
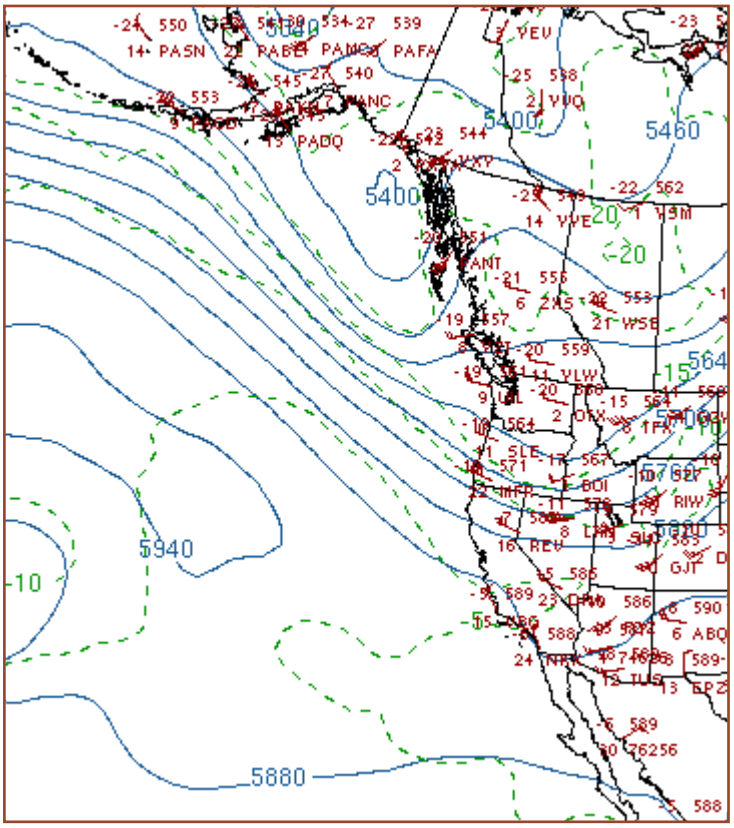


Figure 4: 500 mb Chart 9/12/04 1700 PDT



Weather forecast:

The most current general fire weather forecast for the incident area was done by the National Weather Service in Sacramento, CA, and adequately described the weather conditions for the area (Attachment 1, page 117). No site-specific (Spot) forecast had been requested at the time.

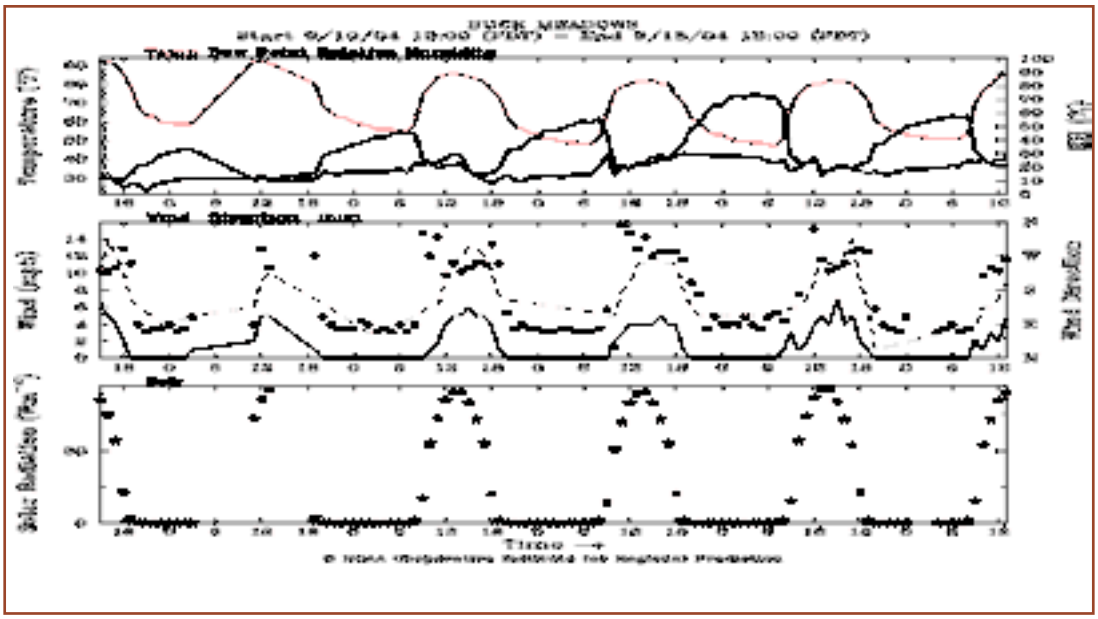
General comments:

The analysis of fire weather conditions surrounding the time of the entrapment must remain speculative due to a lack of on-site measured data or a somewhat representative weather station nearby. The nearest Remote Automatic Weather Station (RAWS) is Buck Meadows, located at the Groveland District Office at Buck Meadows and is about 3.5 miles horizontal distance southwest from the incident site. This RAWS is at an elevation of about 3200 feet near the top edge of the Tuolumne River canyon while the entrapment site was near 1500 feet in the canyon bottom. However, the same data trends recorded at the Buck Meadows RAWS can likely be applied to any airmass changes that occurred in the river canyon as the low pressure trough went through the area.

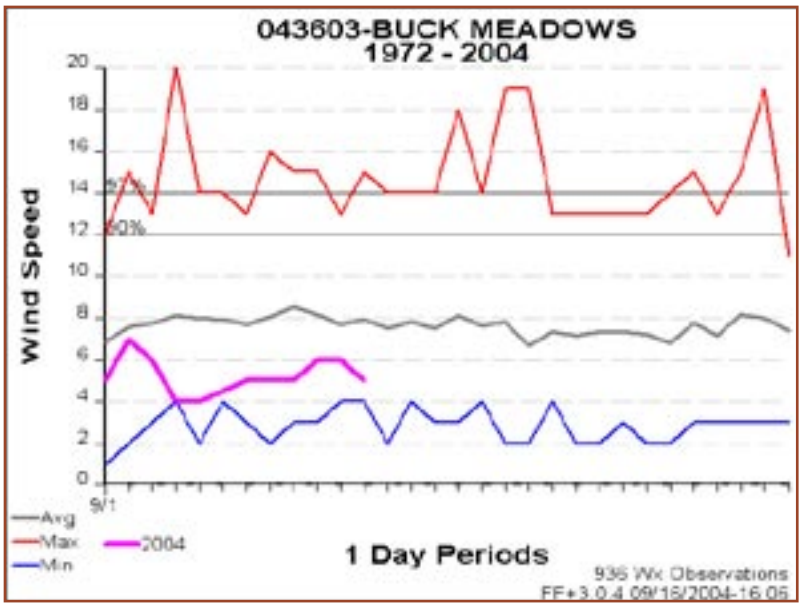
Wind:

As a result of the low pressure trough passing through, wind speeds at the nearby Buck Meadows RAWS were 1 to 2 mph stronger during the day of the entrapment compared to surrounding days (Graph 1). While the general wind direction over the area (SW to WSW) was basically aligned with the Tuolumne River canyon, there is no indication this resulted in stronger than normal winds near the river from air being funneled through the canyon. Wind speeds at the Buck Meadows RAWS were actually below average for the time of year (Graph 2).

Graph 1: 5-day Weather Trends for Buck Meadow RAWS



Graph 2: Buck Meadow RAWS September wind climatology



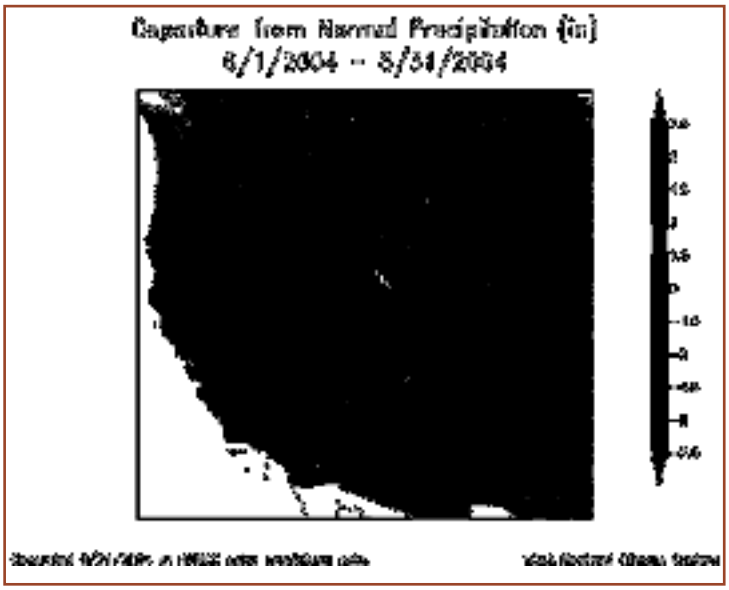
Qualitative reports from witness interviews indicate that the wind on-site prior to the entrapment was steady and up-canyon at three to five miles per hour. This appears very reasonable when watching the smoke drift as captured on the video taken overhead by Air Attack prior to the time of the incident. Witnesses stated there was a sudden change in the wind direction from up-canyon to up-slope (from the river toward the road) causing a flareup which led to the entrapment.

The smoke flow captured on the Air Attack video for the period before the entrapment showed some differences in air motion between sites above versus those below the road. The smoke originating from below the road was moving predominately up-canyon almost parallel to the river. However, it would occasionally flow up-slope (from the river to the road) for brief periods. The smoke flow from the portion of the fire above the road was consistently up-slope with some up-canyon wind influence on its drift.

Prior Conditions:

While a dry summer is common for the area, rainfall for the period June through August was 1.5 inches below normal (Figure 1). The last precipitation prior to the incident occurred on May 28th when RAWS sites in the general area recorded 0.10 to 0.60 inch that day.

Figure 1: Rainfall Departure from Normal June-Aug 2004



Temperatures:

Based on the data from Buck Meadows RAWS, afternoon temperatures in the area were on the order of five to eight degrees cooler than the previous day (Table 3). Allowing for the elevation difference and a canyon bottom location compared to the RAWS site, the temperature is estimated to be somewhere between 89 and 94 degrees on-site at the time of the entrapment.

Relative Humidity:

For much of the day at Buck Meadows RAWS, relative humidities were seven to ten percent higher than the previous day (Table 3), and the afternoon minimum humidity was almost as dry as the day before. Allowing for the elevation difference and canyon bottom location compared to the RAWS site, relative humidity is estimated to be somewhere between 18 and 24 percent on-site at the time of the entrapment.

Table 3: 24 Hour Weather Trends

RAWS Name	Elev/Dist/Dir from Fire	Time	*Temp °F	% RH	Wind Direction	Wind Speed mph	Peak Wind Gust
Buck Meadows	3199 ft 4 mi WSW	16:00PDT	83/-9	16/+6	WSW/ W	5/0	13/0
		15:00PDT	84/-8	17/+7	WSW/ SW	6/+1	13/-1
		14:00PDT	85/-7	23/+12	SW/ W	5/-1	12/0
		13:00PDT	86/- 5	22/+ 11	WSW / W	5/+ 0	11/+ 1
		12:00PDT	85/- 7	21/+ 9	SW / SW	4/-1	10/+ 1
		11:00PDT	84/- 8	20/+ 9	NW / W	2/+0	6/+ 0
		10:00PDT	79/-10	23/+10	W/E	1/+1	6/-1
Mount Elizabeth	4934 ft 19 mi NW	16:00PDT	74/-8	22/+6	WSW/WSW	8/-2	18/0
		15:00PDT	76/-7	23/+8	SW/SW	11/0	18/-1
		14:00PDT	78/-5	23/+10	SW/SW	10/0	18/+1
		13:00PDT	78/- 7	29/+ 16	SW / SW	10/+ 1	17/+ 3
		12:00PDT	78/- 5	25/+ 11	SW / WSW	10/+ 2	15/+ 2
		11:00PDT	76/- 9	26/+ 12	S / SW	7/+ 2	13/+3
		10:00PDT	72/-10	27/+13	S/SW	7/+1	12/0

*Format: current reading/change from 24 hours ago

Conclusions:

The cause of the wind shift at the time of the entrapment is not apparent and does not appear to be an easily foreseeable event. Based on the air flow behavior in the area seen on the video taken for a period prior to the entrapment, it appears that while the predominant on-site wind flow was up-canyon, there were also occasional brief periods with up-slope winds. This strongly suggests the sudden wind direction change witnessed which caused the flareup was part of a localized weather pattern with unpredictable timing.

Local airflow may have been influenced by the physical shape of the terrain in the canyon causing wind eddies. This is common in steep-sided river canyons with convoluted terrain like that in the Tuolumne River canyon. The video suggests the first 75 to 100 vertical feet above the entrapment location may be particularly sensitive to this occurring. Variations in aspect and fuels may have also created localized heating differences that could contribute to changeable air flow patterns. Local airflow may have also been influenced by indrafts into the fire above the road that were occasionally strong enough to briefly override the up-canyon wind, creating occasional wind shifts.

Attachment 1 – National Weather Service Fire Weather Forecast

FIRE WEATHER PLANNING FORECAST FOR INTERIOR NORTHERN CALIFORNIA
NATIONAL WEATHER SERVICE SACRAMENTO CA
730 AM PDT SUN SEP 12 2004

.DISCUSSION...

A LARGE UPPER LEVEL TROF OF LOW PRESSURE WILL DEEPEN OVER THE PACIFIC NORTHWEST TODAY AS A WEAK FRONTAL SYSTEM MOVES THROUGH OREGON/WASHINGTON AND NORTHERN CALIFORNIA. THIS FRONTAL SYSTEM WILL BRING CLOUDINESS TO THE NORTHERN PART OF THE STATE AND SOME COOLING TO NEARLY ALL AREAS WITH AT LEAST SOME MODERATION IN THE VERY DRY HUMIDITIES THAT HAVE BEEN OBSERVED OVER THE LAST SEVERAL DAYS. HUMIDITY VALUES THIS MORNING ARE RUNNING A FEW TO SEVERAL PERCENT HIGHER THAN YESTERDAY MORNING. MORE MODERATE BUT OCCASIONALLY BREEZY CONDITIONS ARE EXPECTED THROUGH MID WEEK AS A SERIES OF WEAK FRONTAL SYSTEMS DIG THE UPPER LEVEL TROF INTO THE GREAT BASIN. ALTHOUGH MORE MODERATE CONDITIONS ARE EXPECTED... AT THIS TIME NO PRECIPITATION IS EXPECTED THROUGH THE EXTENDED PERIOD.

CAZ269-122230-
WESTERN TAHOE WESTERN ELDORADO AND STANISLAUS NF
FIRE WX ZONE 269
730 AM PDT SUN SEP 12 2004

.TODAY...
SKY/WEATHER.....MOSTLY SUNNY.
MAX TEMPERATURE.....76-84 LOWER ELEVS AND 64-69 UPPER SLOPES AND RIDGES.
24 HR TREND.....3-6 DEGREES COOLER.
MIN HUMIDITY.....15-25 PERCENT.
24 HR TREND.....7-12 PERCENT WETTER.
20-FOOT WINDS.....
VALLEYS/LWR SLOPES...SOUTHWEST WINDS 5 TO 12 MPH.
RIDGES/UPR SLOPES....SOUTHWEST WINDS 12 TO 18 MPH.
LAL.....1.
CWR (>0.10 IN).....0 PERCENT.

.TONIGHT...
SKY/WEATHER.....MOSTLY CLEAR.
MIN TEMPERATURE.....51-61 LOWER ELEVS AND 37-45 UPPER SLOPES AND RIDGES.
24 HR TREND.....2-4 DEGREES COOLER.
MAX HUMIDITY.....30-45 PERCENT.
24 HR TREND.....5 PERCENT WETTER.
20-FOOT WINDS.....
VALLEYS/LWR SLOPES...NORTHWEST WINDS TO 8 MPH.
RIDGES/UPR SLOPES....NORTHWEST WINDS 7 TO 15 MPH.
LAL.....1.
CWR (>0.10 IN).....0 PERCENT.

.MONDAY...
SKY/WEATHER.....MOSTLY SUNNY.
MAX TEMPERATURE.....73-81 LOWER ELEVS AND 61-66 UPPER SLOPES AND RIDGES.
MIN HUMIDITY.....18-28 PERCENT.
20-FOOT WINDS.....
VALLEYS/LWR SLOPES...NORTHWEST WINDS 5 TO 12 MPH.
RIDGES/UPR SLOPES....NORTHWEST WINDS 12 TO 18 MPH.
LAL.....1.
CWR (>0.10 IN).....0 PERCENT.

Appendix E

Fire Behavior

Appendix E—Fire Behavior as Described by Observers

The accident investigation panel members interviewed each of the major participants in the initial attack firefighting response for the Tuolumne Fire for the Copter 404 Burnover. Interviewees were requested to describe the events on September 12 and asked specific questions on tactics, communications and safety. The interview panel met with most of the participants on September 14 and 15, 2004 and conducted some follow-up interviews a few days later. During these interviews, the observers provided descriptions of fire behavior. Although their accounts of location, distance and time varied, the witnesses agree with each other fairly well. Since the witnesses participated in the firefight from different locations and were experiencing physical and emotional trauma it is reasonable to expect some variation in the narratives.

The following individuals contributed to this compiled description:

Dan Ward	AA440 ATGS
Colin Rogers	Air Attack 440 Pilot
Alan Johnson	Incident Commander
Tom Eggleston	Copter 404 Pilot
Frank Podesta	Copter 404 Captain
Jonah Winger	Crew 404 Helitack Captain
Josh Agustin	Copter 404 Firefighter
John Andahl	Copter 404 Firefighter
Jeff Boatman	Copter 404 Firefighter
T.J. Fraser	Copter 404 Firefighter
Shane Neveau	Copter 404 Firefighter
Tammy Mount	Engine 43 Captain
Brian Austin	Engine 43 Firefighter
Russell Looney	Air Tanker 81 Pilot
Crewmembers	Engine 4476 and Engine 4456
Duane Cornell	Air Tanker 82 Pilot
Jim Dunn	Air Tanker 83 Pilot

Observed fire behavior will be summarized before, during and after the flareup event. Since Lumsden Road is an access route that provides a reference point for observers, fire behavior above and below the road will be presented sequentially.

Before the flareup below Lumsden Road as described

Upon arrival of the initial attack resources, the fire was backing down-canyon (toward the southwest) against an up-canyon wind. Flame lengths were described as less than 1 foot by the Incident Commander (IC) who drove to the right flank a few minutes before Helitack Crew 404 reached the line. Upon arrival, Helitack Captain (HC) Winger checked the lower right flank below Lumsden Road. The fire contoured down-slope but bent up-canyon toward the northeast. The fire below the road was aligned fairly closely with its extension above the road. The fire was creeping slowly down-canyon.

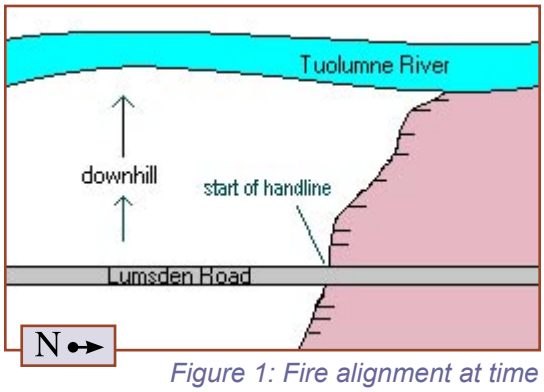


Figure 1: Fire alignment at time of initial ground attack. Pink area represents burn.

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During this same period, aerial videos showed smoke originating from below the road to be spreading up-canyon, parallel to the river.

Copter 404 made no bucket drops below the road.

As the fire appeared to be spreading favorably, Helitack Crew 404 prepared to construct handline on the downhill portion of the fire. Crewmembers described the flames as being one foot or shorter.

As the first 100 feet of the cut line extended down-slope, the fire continued to back down-canyon toward the crew working on the handline. Cut materials were thrown to the left of the handline (into the green). When the scrape had extended about 60 feet down-slope to a dogleg, crewmembers used a fusee to burn out the fuel between the handline and fire. Fire was extended about 20 feet down the line to the base of a large pine.

HC Winger and crewmembers assert that the constructed handline was about 10 feet from the backing fire edge. HC Winger advised that the sawyer cut line below the dogleg was not the same as his planned handline. The sawyer had cut too far to the south from where he intended to proceed. From the dogleg he intended to angle to the right toward the fire on somewhat of a contour.

The interviewed members from Helitack Crew 404 and aerial observers from Copter 404, AA440 and the air tankers were consistent in reporting benign backing behavior with short flame lengths along the lower right flank during the entire observed period prior to the flareup.

Before the flareup above Lumsden Road as described

ATGS Ward observed that the fire above the road had crested the ridge and had dropped onto the (north-facing) lee of the hill. Here the fire exhibited lessening intensity and speed. The air tankers and Copter 404 appeared to be effectively holding the right flank above Lumsden Road. The copter made 6 to 7 bucket drops.

As the fire spread higher in the canyon (toward Cherry Road) it appeared to catch more of the upper gradient winds. About one hour into the fire (estimated around 1328 hrs), a spot fire was sighted mid-slope off the left flank at about 2400 feet elevation. Copter 404 responded and was effectually limiting this spot with two to three water drops. Later, additional spotting activity was observed higher up the slope.

The head of the fire began moving southeast toward the top of the canyon. IC Johnson and ATGS Ward discussed their plan for expanding the suppression forces responding to the incident. They ordered additional aircraft, ground resources and overhead personnel and then directed incoming resources toward the area of Cherry Road and Drew Meadow.

The right flank was smooth and appeared to be backing evenly.

Smoke was spreading up-slope and up-canyon. The up-slope vector was more observable on upper elevations and was more notable during the short runs that occurred. Smoke originating near the heel tended to spread up-canyon rather than up-slope. Spotting activity was never observed on the right flank of the fire.

The flareup below the road as described

Helitack Crew 404 was spread out along their handline that was under construction. The lowest cut was 100 feet below the road but the scraped portion had extended about 50 feet. The captain of Engine 43 approached the top of the handline and observed Helitack Crew 404 working. The fireline immediately above the road appeared to be inactive.

As E-43 Captain Mount arrived near the top of the handline, she observed a spot fire on the road cut-bank across from the top of the handline. The spot fire spread southward along the cut bank about 35 feet and then to the slope above. Within an estimated 10 to 15 seconds, the fire from the vicinity of Helitack Crew 404 was blowing across the road near the head of the handline.

From the crew's perspective, as per their testimony, the following events progressed from the bottom of the proposed handline up toward the road. Each testimony reflects the witness' observations from his own location on the line.

FF Jeff Boatman advised that the backing fire had been underburning some of the brush and that their handline placement took advantage of a natural break in the ladder fuels. After the crew was working, he noted a small wind shift and some parallel fire. He was told to get the backpump. Somebody yelled and he saw a wind shift and crewmembers scattering with the fire coming up the hill. He yelled and backed from the road edge. He heard Schicke scream and saw Neveau arrive at the top as the fire hit the road. (Boatman was 1st from the top).

FF Shane Neveau had been firing-out the area between the fire and the new handline. He bumped up against Schicke so he threw away his fusee. He saw a tiny "flicker" of wind change and then a major wind change with torching below him. He yelled "Wind Change!" and "Get Out!" He turned and ran uphill and felts heat at his back. He rolled into the cut bank and tried to deploy his shelter while on the ground but he got up and ran to the black instead. He asserted that the firing-out operation was not related to the flareup. (Neveau was 2nd from the top).

FF Eva Schicke was 3rd from the top. During her escape attempt, she may have reached within 5 feet of the road.

FF John Andahl heard Neveau yell "wind change!" and saw fire racing up from below. He saw a hole in the flame height and ran through it, downhill to the right. The hole disappeared as he was in it. He ran through blindly, hit a tree and then landed on the rocks. He received burns on the left side of his face and other mechanical injuries. (Andahl was 4th from the top).

HC Jonah Winger saw a giant wind shift and saw fire spreading up the flank toward Helitack Crew 404 from below. The fire was somewhat in the canopy. He yelled "Emergency Action!" He ran down through the fire. In a subsequent interview HC Winger provided a diagram showing approximate site conditions. (Winger was 5th from the top).

FF Josh Agustin was the brush puller and he estimated that he was 4-5 feet from the black. The fire was backing, underburning and not consuming the brush. The flame length was about one foot. Agustin saw a wind shift and fire sheeting up below him in the grass and then it died slightly. (There was not much brush in the vicinity.) He yelled to FF Fraser. The fire sheeted up a second time and was spreading into his piled brush. He jumped downhill, eventually landing on top of Fraser on the riverbed. He described the sheeting action as fire about 8 to 12 inches tall and 10 to 15 feet deep, spreading (left) 10 to 15 feet into the green with intense heat. (Agustin was 6th from the top).

FF T.J. Fraser was the saw operator. He dumped his cut material to the left (toward the green). Brush near the bottom of the cut was very sparse. He saw a wind shift and heard yelling. He set his saw brake and ran past the flames. He did not take any heat or smoke as he escaped. As he looked back uphill, he could see the fire running uphill and could see Winger and Andahl come down. (Fraser was 7th from the top).

The various crewmembers described the fire event as taking 8 to 30 seconds. From the air, the event appeared to take 15 to 20 seconds, (max 30 sec as per ATGS440).

The flareup above the road as described

From the air, increased intensity was observed on the southwest-facing portion of the right flank above Drew Creek. This fire run was headed up-slope but moving slightly down-canyon. Smoke from the run, however, still appeared to be moving up-canyon. Aerial observers did not perceive a directional change in the smoke that indicated a wind change with a southeastern component. The right flank of the fire was still close to the ridge.

Aerial observers give somewhat differing accounts of fire activity on the right flank at the time of the flareup. According to ATGS440, after increased behavior on the upper slope was noted, increased intensity was then seen near the lower right flank at Lumsden Road. The fire near the road appeared to be unconnected from the increased behavior on the upper slope and delayed somewhat behind it (30 seconds as per ATGS). The lower fire appeared to start from below the road then carry slightly above the road. It was this fire activity near the heel that triggered ATGS Ward's command for crewmembers to get into the black (especially since he believed them to be working above the road at the time). ATGS Ward commented that the fire did not appear to spread much above the road. According to the pilot of Airtanker 81 however, fire spread was progressive from the bottom to the top.

The fire run progressed in a narrow band along the right flank of the fire.

From Engineer Craddock' s perspective in E4476 approaching South Fork Campground from the west, the fire buildup high on the ridge appeared to occur before the increase near the heel.

From the air, the fire below the road appeared to have moved in a narrow wedge about 15 yards down-canyon. The right flank near the road was aligned more vertically from the pre-flareup condition. Down in the new black, crewmembers estimated that fire had spread about 50 feet south of the handline.

Post-flareup above the road as described

As Engines 4490 and 4476 approached the rocky turnaround from the southwest, they could see the chamise burning above them. They had concerns about their engine safety close to the draw. By the time they got to the right flank to assist with the search, the fire behavior immediately above them had died down.

The pilot of AT 81 observed that the entire fire run moving up the right flank took 4 to 5 minutes. The Hollister airtankers made their first drop (using jel) after the flareup and after Copter 404 began making rescue drops during the search for FF Schicke. The jel drops are clearly visible in post-fire photos and mark the fire's edge soon after the flareup.

On the upper slopes after the initial run, the fire began backing down the ridge toward Drew Creek. The right flank above the road backed somewhat south of the below-road segment. Later, Deadwood crews extend a handline up the right flank, which then paralleled Drew Creek.

Post-flareup below the road as described

After the captain of E-43 felt that the fire was not likely to take another run, she backed her engine toward the black to assist. E4490 and E4476 also responded.

After the flareup, the fire returned almost immediately to the previous backing behavior.

When responding to the call for bucket drops the copter pilot and captain observed few specific targets for bucket drops. Aerially visibility was described as fairly good but ground observers who were searching for the missing firefighter were hampered by heat and smoke.

Bucket drops began to put water on concentrations of heat. The fire's spread to the west was stopped. Later, crewmembers from E-43 and other firefighters constructed a handline and extended a hose-lay from the road down to the river.

Appendix F

Fire Behavior Modeling

Appendix F—Fire Behavior Modeling On the 9/12/04 Tuolumne Fire

Fire behavior modeling is an appropriate part of a burnover investigation. Modeling can help describe and explain the fire behavior observed and demonstrate the extent to which the behavior was predictable. Fire behavior modeling can also identify where site conditions are more hazardous or less hazardous, thus providing guidance in setting safer firefighting tactics.

Even though BEHAVE and other fire modeling programs have documented assumptions and limitations they can be used to demonstrate relative fire behavior between differing small sites.

Modeling Assumptions on the Tuolumne Fire

Live Woody Moisture

CDF Units and USDA National Forests conduct live fuel moisture monitoring. Usually only chamise *(Adenostoma fasciculatum)* and manzanita *(Arctostaphylos spp.)* are tracked. These plants are suitable because they are common throughout the state and often impact the burning conditions encountered by wildland firefighting agencies. Other shrub species also burn and contribute to fire behavior. Their own live fuel moisture and flammability parallel those of chamise and manzanita, responding to the same soil moisture and weather conditions.

Chamise and manzanita were both present within the Tuolumne Fire. In the immediate area of the accident however, chamise was not present and only a small component of manzanita contributed to the fire behavior. Toyon and live-oak shrubs were the predominate brush species. Nevertheless, chamise and manzanita provide an indicator of flammability for other brush species that were present. The overall live fuel moisture can be inferred. The most recent live fuel moisture readings from the Tuolumne Calaveras Unit were 54% for chamise and 55% for manzanita (8/31/04). These reading are in line with numbers coming from adjacent CDF units and National Forests. They reflect the seasonal low-point and indicate potential critical fire behavior. For modeling purposes, Live Woody Moisture of 50 percent was used.

Fuel Models

Fire behavior analysts choose a fuel model that best represents how a fire burns under specified weather conditions. Although fuel models are classified by vegetative characteristics, they are selected for fuel characteristics that best represent their burning behavior. In the area of the accident, fine dead fuels (1-hour) drive the fire's rate of spread. Cured grasses and dry oak leaves provided the fine fuels that contributed most to the fire spread. Fire modeling in this exercise will use FM2, reflecting a grass and leaf surface layer with an overstory of oak and pine. The brush component around the accident site contributed to the flame length and intensity and provided a ladder effect, supplying loft to embers and heat. This brush component is less represented in FM2 and may be better modeled with a different fuel model. Alternative fuel models are explored in the following analysis.

Site Weather Conditions

Accident site weather conditions are based on fire weather analysis prepared by Brenda Graham, USFS Meteorologist:

Temperature: 90 degrees Fahrenheit
Relative Humidity: 20 percent
Midflame Wind Speed: 4 mph

Time-lag Dead Fuel Moisture

Calculation of 1-hour fuel moisture: Table A factor + Table C correction
(Rothermel, Fire Behavior Field Reference Guide)
Table A fuel moisture: 3 %
Table C correction (exposed fuel, 1200 hrs, L= =/- 1000 feet, aspect: West, 31+%): 2 %

1-hour Fuel Moisture = 3 + 2 = 5 percent
10-hour Fuel Moisture = 1-hr FM + 1% = 6 percent
100-hour Fuel Moisture = 10-hr FM + 1% = 7 percent

Topography Factors

Aspect at accident site WNW: use 290 degrees (azimuth from north).
Wind direction: Up-canyon originating from SSW; use 200 degrees (from north)
Slope: 90 percent

BEHAVE Modeling Predictions

Inputs

Fuel Model 2
1-hour 5%
10-hour 6%
100-hour 7%
Live fuel moisture 50%
Midflame Wind Speed (MWS) 4 mph

Outputs

Fuel Model 2

Fire Description	ROS (ch/hr)	FL (feet)	Spread Direction degrees	Spread Direction description
Backing Fire, steady wind	3.7	2.3	200	downcanyon-lateral, SSW
Head Fire, steady wind	66.4	8.6	84	upcanyon-upslope, East
Upcanyon spread	8.7	3.4	20	upcanyon-lateral NNE

ROS – predicted rate of fire spread in chains per hour. A chain is 66 feet.
One chain per hour is 1.1 feet per minute.
FL – predicted flame length in feet.
Spread Direction – predicted in degrees from north.

The predicted behavior of a head fire compared to that of a backing fire has nearly 4x the flame length and 20x the rate of spread. Firefighters on the Tuolumne Fire reported that the flame length of the backing fire below Lumsden Road was about 1 foot. There are no ground-based fire behavior observations for head-fire near or the Lumsden Road however. At the time of arrival of line personnel, the head was burning on the ridge in chamise and chaparral, a substantially different fuel type than near the burnover site or fire origin. The FM2 predictions appear reasonable and compare favorably with observed conditions near Lumsden Road during the period before the flareup.

Witnesses described a wind shift at the time of the accident. If a wind shift is modeled from upcanyon to up-slope, the wind source changes from SSW to WNW (200 degrees shifted to 290 degrees). Even without a change in wind speed, (4 mph) the expected increase in fire behavior would be:

ROS (ch/hr)	FL (feet)	Spread Direction (degrees)
87.8	9.8	110 directly up-slope

This is a 24x increase in rate of spread [87.7 ch/hr = 96 feet/minute] and a 4x increase in flame length shifting from backing behavior to head fire behavior for the site where Helitack Crew 404 was building a handline.

In mountainous terrain, temporary shifts in wind direction are often accompanied by gusts. A moderate wind increase (gusts to 7 mph) added to the change in direction provides the following projected fire behavior:

ROS (ch/hr)	FL (feet)	Spread Direction (degrees)
137.0	12.0	110

Fire behavior becomes notably more intense. [137.3 ch/hr = 151 feet/minute]

Under a common shift in wind direction or one that includes a modest gust, predicted fire behavior would be notably more intense than of a backing fire. These predictions compare favorably with the flareup behavior observed by Tuolumne Fire line firefighters.

Alternative fuel models

Fuel Model FM2 may not fully describe the fire behavior because of model limitations and fuel variation at the site. Comparisons with FM6, FM4 and FM9 were explored during behavior modeling.

Fuel Model 6

Description	ROS (ch/hr)	FL (feet)	Spread Direction (degrees)
light brush, 4 mph wind	72.0	8.9	110
light brush, 7 mph wind	101.1	10.4	110

This FM6 predicted behavior for a head fire is not much different than the FM2 above, but has a significantly different fuel description.

Fuel Model 4

Description	ROS (ch/hr)	FL (feet)	Spread Direction (degrees)
heavy brush, 4 mph wind	250.6	36.0	110
heavy brush, 7 mph wind	356.3	42.3	110

This calculation is an extreme jump in predicted behavior for a head fire and does not compare well with observed behavior. The FM4 model is probably too heavy for the incident site, in spite of cut vegetation that may have contributed to the flareup.

Investigating the use of FM9-Hardwood-litter might be appropriate because the accident site's oak leaves and sparse grass are similar to the vegetation description identifying this model. A backing fire (spreading down-canyon toward the WSW) has the following predicted characteristics.

Fuel Model 9

Description	ROS (ch/hr)	FL (feet)	Spread Direction (degrees)
light hardwood, 4 mph (backing)	.8	1.0	200 (down-canyon)
hardwood-litter, 4 mph (head)	18.6	4.3	110 up-slope

This predicted slow backing fire with short flame length is very similar to the observed behavior before and immediately after the flareup. However, for the up-slope wind change using the same FM9, fire behavior is not very significant. This model does not appear to model observed fire behavior except under low-intensity conditions.

Analysis Summary

- In August 2004, fuel moisture for live chaparral fuel was at a seasonal low point throughout the Sierra. Fire behavior can be expected to be extreme when live fuel moisture is below the critical level.
- Fire behavior modeling can be useful in demonstrating relative fire intensity for specific small sites. Fuel Model 2 best predicts overall fire behavior at the accident site.
- A change in wind direction from up-canyon to up-slope on extremely steep slopes will cause a large increase in fire behavior.
- Extremely steep ground by itself can lead to intense fire behavior. It also creates hindrances to fire control efforts and should have a multiplier effect on safety considerations.

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BEHAVE Fire Behavior Prediction and Fuel Modeling System. [Developed in Missoula, Montana by the Forest Service Intermountain Research Station. BEHAVE is supported by USDA Forest Service, Washington Office, Fire and Aviation Management.]

Appendix G

Fire Behavior Conclusions

Appendix G—Fire Behavior Conclusions

The fire behavior and flareup on the Tuolumne fire associated with the entrapment on the afternoon of September 12, 2004, was a direct consequence of the combination of fuel, weather and topographical factors. The alignments of fire environment factors and the resulting fire behavior were normal and predictable.

Current and past fire behavior often does not indicate the potential fire behavior that could occur.

Maximum possible fire spread and flame lengths are estimated by comparing present fuels, weather, topography and the current fire behavior with predicted or anticipated changes in fuels, weather and topography and past experience of extreme fire behavior on other fires. Previous experience and observations of fast spreading, high intensity fire behavior and training in fire environment assessment are tools that should be used to anticipate potential fire behavior.

The fire behavior exhibited on the Tuolumne fire below the road prior to the flareup consisted of low intensity, lateral flanking fire spread which was moving cross-slope at 1 to 3 feet per minute with flame lengths of one foot or less. Initial attack responders described and the air attack video confirmed, a consistent backing fire on the lower right flank prior to the flareup. During this period, there were no wind shifts or indicators of increased fire behavior where Crew 404 chose to construct fireline. The observed low intensity fire behavior may have given firefighters a false sense of security, even though existing conditions of fuel, weather and topography were critical.

The transition from a slow spreading, low-intensity fire to a fast-moving, high intensity fire often occurs rapidly.

This seems to surprise firefighters most often in live fuels, possibly because green vegetation is associated with reduced ignition risk. We do not fully understand the exact mechanisms triggering these transitions. However observations of past fire behavior indicate that such transitions often occur when there are changes in wind speed or direction, fire location (top of the slope versus base of the slope), or in the quantity of live and dead components in the vegetation canopy. Live green vegetation can support and even promote high-intensity, fast spreading fire behavior. Assessment of the position of the fire relative to the alignment of wind, slope and live and dead fuels can assist firefighters in recognizing potentially hazardous fire behavior.

Complex interactions between fuels, topography, weather and the fire can dramatically influence the local wind patterns.

Local airflow and small-scale winds may have been influenced by topography (physical shape of the terrain), variations in aspect and fuels and indrafts into the fire above the road. The complex interaction of these influences most likely caused the change in wind direction witnessed on the fire.

Critical live fuel moisture values contributed significantly to the increased fire spread and intensity associated with the flareup.

Critically low live fuel moistures contributed to the rapidly spreading high intensity fire behavior observed during the flareup. Live fuel moistures sampled in close proximity to the accident site on September 17, 2004 were at critical levels for both chamise and manzanita. Live fuel moistures for both chamise and manzanita were routinely sampled on the Tuolumne-Calaveras Ranger Unit (approximately 20 miles northwest of the incident) and had been at critical levels since July 28, 2004.

Predicted fire danger indicated critical environmental conditions.

The forecasted weather for September 12, 2004 could be characterized as fairly normal for a mid-September day. However, the National Fire Danger Rating System (NFDRS) indices tracking seasonal trends indicated extreme fire behavior. Energy Release Component (ERC) was at a record maximum value (86) and 1000-hour fuel moisture was at a record minimum value (7%) for a 33 year period at the nearby Buck Meadows RAWS station.

Escape route travel time is related to topography, route length and potential fire behavior.

Escape routes should be considered in relation to potential maximum-intensity fire behavior rather than past or present fire behavior. The ideal escape route includes a downhill direction over the shortest possible distance to the safety zone, thereby maximizing firefighter travel rates toward areas with minimum fire spread. Escape routes uphill to the road were sufficient for the low intensity flanking fire behavior observed prior to the flareup but were not adequate for the fire behavior experienced during the flareup.

Appendix H

Site Examination

	SUPPLEMENTARY INVESTIGATION REPORT STATE OF CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION (LE-71)	ORIGINATORS CASE NUMBER Site Examination Report

CASE TITLE	MONTH	DATE	YEAR	COUNTY	REG	RU	INCIDENT #
Tuolumne Fire Accident	Sept.	12	2004	TUO.	CSR	STF	CACSR000116

CDF Helitack Crew 404 Burnover Site Examination

Summary

On September 13, 2004 at 10:00 a.m. I reported for assignment to the Tuolumne Fire Serious Accident Investigation in Sonora, California. During the initial meeting of the accident investigation team I was assigned by lead investigator Mike Cole the responsibility of conducting the on-site investigation of the accident scene. On the afternoon of September 13, 2004, I accompanied the investigation team to the accident site and conducted a general overview of the accident site without leaving Lumsden Road, which is located at the top of the general accident site.

During the following week and a half, I conducted almost daily examinations of the accident scene, which included identifying, protecting, documenting and collecting physical evidence. I also conducted an evaluation of burn pattern indicators to determine the spread of the fire through and near the accident site.

During this same period of time, I coordinated the surveying of the general accident area site by licensed contract surveyors. The task of the surveyors was to accurately document the topography of the site and placement of key physical evidence items. CDF Fire Captain Denny O'Neil assisted me in this task. The surveying company also took high-resolution aerial photographs.

Review showed that the original spread of the fire was primarily up-canyon and up-slope to the northeast. Backing and lateral indicators on the right flank of the original fire spread indicate a slow to moderately burning fire that spread cross-slope into an up-canyon wind towards the accident site to the south. Occasional moderate runs and torching are evident where surface fuels and brush were mixed and fire spread into the brush from below. These areas were small in size and mixed among the total burn area.

Below the road, between the right flank of the fire and the accident site, evidence indicates that rock outcrops and dirt chimneys restricted the cross-slope fire spread against the wind and towards the accident site at scattered locations. Burn indicators show that an area of backing fire worked its way across the slope and entered the general accident site near the lower quarter of the slope (between the road and river). Fuel remains and burn indicators in the area just up stream of the accident site are consistent with a low intensity ground fire burning in light grass and leaf litter.

At the same time that the fire was backing across the hill towards the accident site below the road, fire on the uphill side of Lumsden Road further to the north was backing across the slope to the south at a much more rapid pace in more consistent fuels. Just prior to the accident, the fire above the road was about 10-30 feet behind or to the north of the fire below the road with indications that further up the slope it was even further to the south. This fire above the road was burning in heavier fuels and was burning faster across-slope and hotter than below the road as indicated by heavy white ash deposits above the road. Fire just above the road had established itself in a dead snag near the fire's edge and about forty feet up-slope from the road. The snag was burning about forty feet off the ground.

Physical evidence on the ground in the form of cut brush, supports statements by Helitack 404 crewmembers that they were constructing indirect fireline from the road downhill. Saw work had

continued to within thirty feet of the high water level of the river as indicated by the lowest saw cut on the hill. The crew was spread out along the line from the road to this location. Burn indicators near the top of the line show a moderately hot fire burning in the area just inside the line and up to the road with lateral and backing indicators, both into the fire and downhill from that location to about twenty-five feet below the road, consistent with statements of the crew firing-out in this area.

Witness statements indicate that a small spot fire established itself at the base of the cut bank on the inside edge of the road. This spot fire was located across from the top of the line location and burning out operation of Helitack Crew 404. It was also downhill and to the south about thirty feet from the snag, which was on fire above the road. Burn indicators support witness statements that this spot fire spread rapidly across the face of the cut bank to the south for about thirty feet and then turned up-slope.

Burn indicators support statements by HC Winger and other witnesses that almost simultaneous to the spot fire taking off on the cut bank, a fire front came across the slope towards the position of the lower four members of Helitack Crew 404. Burn indicators show that this fire front was burning moderately hot in the surface fuels with some individual torching of brush. There was no indication of fire spreading to the crowns in this area or large-scale fire in the brush.

Witness statements indicate, and burn indicators show, that this cross-slope fire picked up speed and intensity as it turned up-slope near the location of the line construction. Ground fire indicators show the fire burned under the scattered brush until it reached a location below a continuous stand of brush at which time it gained intensity and began to be carried in the brush itself. Burn indicators show this run in the brush to have been rapid and sustained for about forty-five feet up the hill and about thirty feet wide inside the line. As this fire neared the area fired-out by the crew, about twenty-five feet below the road, it subsided on the left shoulder of the run while the right shoulder continued as an advancing fire and crossed over the line and ran up toward a large oak tree just below the road.

Burn indicators show that an additional spread of this fire from below made its way around the end of the cleared handline and burned up-slope in light grass, leaves and cut brush, toward the road. This fire fingered out to the south in a narrow, but short, run. The heat from this additional burning combined with the fire burning across the line in the brush and followed it up-slope to the road where the spot fire had already turned up-slope and burned beyond.

Physical evidence recovered from the scene along with witness statements indicate that the victim and one other firefighter were above and in the area of this fire front at the time it ran across the line and to the road. Witness statements and burn indicators show that the fire hit the road and quickly subsided.

Investigation of the area above the road shows that about fifty feet above the road and to the north of where the spot fire had turned up-slope, an advancing fire front had established itself and was burning extremely hot in grass, leaf litter and brush over an area about one-quarter acre in size. Burn indicators show that this fire was burning with the wind (opposite the direction of burning below the road prior to the fire run) and with the slope in a southeasterly direction. This fire was joined by the spot fire from the cut bank and together they continued a short but hot run over the ridge which separated the west aspect slope of the accident scene and the south aspect slope facing Drew Creek to the southeast. This fire then turned up ridge and up-slope, burning in nearly continuous chamise brush fuel and made a narrow run toward the main fire activity further up this ridge.

During the investigation, consistent up-canyon or down-slope winds were witnessed below the road at the accident site. Up-slope or down-canyon winds were never witnessed on the accident site during the week and a half of daytime on the ground investigations by four investigators. Above the road, wind direction was repeatedly observed to change from up-canyon to down-canyon and from up-slope to down-slope over short periods of time in the afternoon. Gusts of wind were observed flowing down-canyon and wrapping around the ridge line separating the west aspect of the accident site and the south aspect in Drew Creek drainage.

Conditions

The accident site is located at the 1450 feet elevation near the bottom of the Tuolumne River canyon. While the Tuolumne River generally runs east to west, at the accident site the river canyon turns and runs nearly north to south. This turn in the river is formed by a ridge, which juts into the river course from the northwest, just downstream and west of the accident site. This ridgeline affects the up-canyon airflow. Granite rock outcrops in many places form the canyon sides just above the river bottom itself. Slopes near the bottom of the canyon at the accident site run from 80 to 120 percent with vertical drops in some locations near the river edge.

Drew Creek is a tributary of the Tuolumne River and flows into main river canyon just south (downstream) of the accident site. Drew Creek flows generally from the east; its south facing slope, on the fire side of the drainage, is covered primarily with chamise brush less than 17 years old.

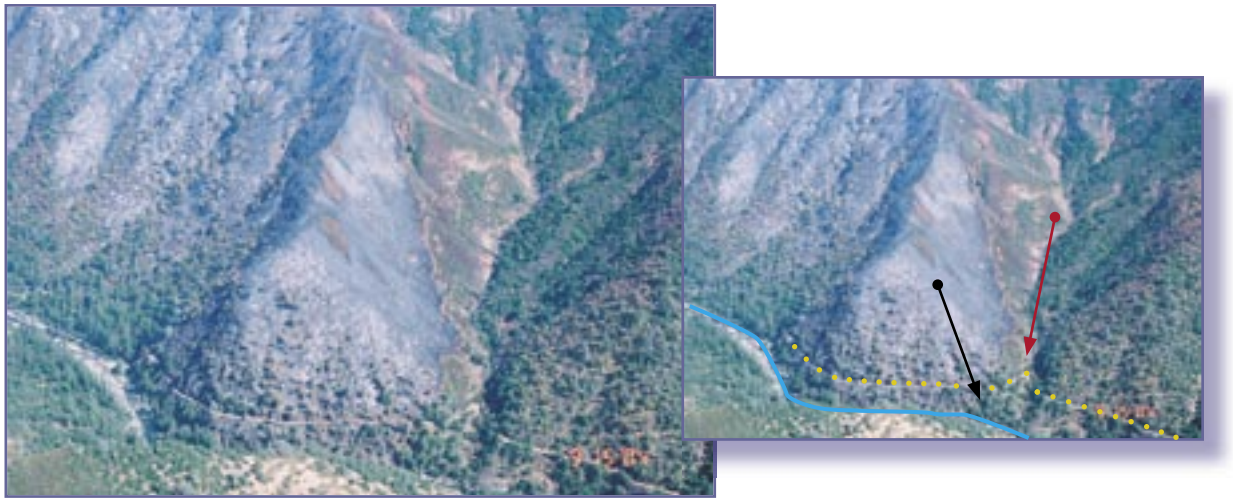

Photo H-1. View of lower fire area and accident scene. Tuolumne River (blue line) runs from lower left side (upstream) to lower right of photo (down stream) with north to the left of the photo and south to the right. Photo taken generally from west to east. Drew Creek (red arrow) is visible to the right of burned area. Lumsden Road (yellow dotted line) runs above the river on the southeast side and is visible near the bottom of photo. Accident site (black arrow) is located on the slope below the road and just above the river, just inside the right flank.

The lower end of the fire and accident site are reached by a dirt forest road named Lumsden Road, which comes from the southwest rim of the canyon about six miles away. As Lumsden Road approaches the accident site it drops to near the bottom of the canyon and passes Lumsden campground, crossing several side drainages, the last one before the fire being Drew Creek. At the accident site, the road is about 260 feet above the river bottom and is a one-lane dirt roadway with steep cuts in the hillside. Lumsden Road continues up-canyon for about another three-quarters of a mile where it crosses Lumsden Bridge.

The general accident site is on a primarily west aspect below Lumsden Road. Multiple shallow chimneys running from above the road to the river bottom bisect the slope near and at, the accident site. These shallow chimneys have increased slopes and loose soil with sparse fuels in them. Rock outcrops are scattered across the slope in pockets and along minor ridgelines. A shallow chimney runs from the top to the bottom of the accident site and forms a portion of a debris channel, which collects rolling or sliding debris from the top of the fire line (at the road). Debris is funneled down this channel to a rock outcrop about mid-slope within the accident site. This natural debris channel continues over the rock outcrop and down the slope until it nears rock cliffs near the river. At this point the debris channel turns slightly to the left (looking downhill) and drops to the river rocks below.

Photo H-2. Photo of accident site with Lumsden Road visible in upper photo. Line construction left the road between gray pine and large oak below the road (black arrow) in upper right corner of photo. Dark ash area (red line) below and to the left of gray pine is remains of brush patch. Line construction came around right edge of this burned area and underneath it prior to turning down-slope again. Victim's body recovered in shadow located to right of center (red arrow), right and above burnt logs on hillside.

The west-aspect slope of the general accident site continues up-slope above the road about 400 feet to a ridge which separates it from the generally south-facing slope on the northeast side of Drew Creek. Slopes above the road moderate to less then 100 percent except where isolated rock outcrops exist. Surface fuels at the general accident site below the road consist of leaf cover and sparse short grass about one foot tall. Scattered brush and brush patches are intermixed with small openings of dry grass and oak trees. Gray pines are scattered sparsely across the slope. The south-facing slope in the Drew Creek drainage is covered almost entirely by continuous chamise brush with light grass underneath. The slope above the road and above the accident site has more consistent ground fuel consisting of leaves and grass along with more dead and down brush and oak fuels as indicated by ash residue.

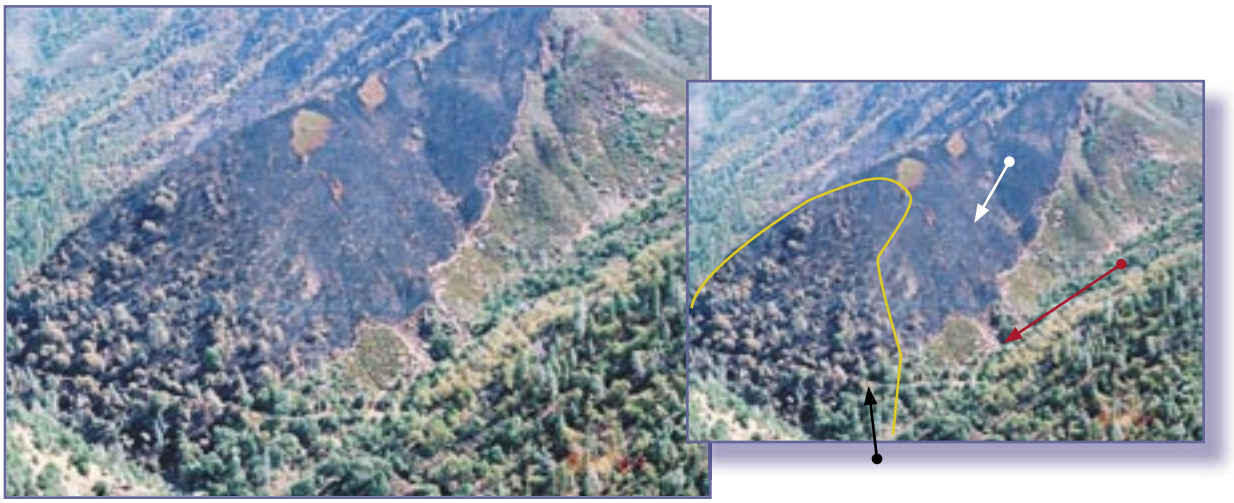

Photo H-3. View of west aspect slope (yellow line) shown in lower left corner. Drew Creek in right of photo (red arrow). South aspect (white arrow) above Drew Creek visible above it. Ridge and fuel transition from west aspect to south aspect visible just left of center. Accident site (black arrow) below road along right flank near bottom of photo.

The original fire spread, below Lumsden Road, included up-canyon advancing fire and a backing fire down-canyon and down-slope into a generally up-canyon light wind. Burn indicators above the road show that the fire here burned hotter and faster than the fire below the road.

Burn indicators support reports by the crew of Copter 404 that at the time of their arrival at the general accident site, the right flank of the fire below the road was backing into an up-canyon wind. The right flank of the fire above the road was about 10 to 30 feet north of (past) the fire's edge below the road. Witnesses indicate that burning conditions included a slow burning backing fire with flame lengths of about one foot. Burn indicators show that short up-slope runs of fire in surface fuels partially torched occasional scattered brush.

While specific wind conditions prior to the fire above the road are unknown, during the course of one and a half weeks of on-site investigation certain wind conditions were noted. Winds below Lumsden Road were noted to begin a general up-canyon flow at about 11:30 a.m., with a steady light to moderate up-canyon flow by 12:00 noon. At the general accident site, down-slope winds were frequently observed mixing with the up-canyon flow. At no time were down-canyon or up-slope winds observed during the hours between 10:00 a.m. and 5:00 p.m. Winds above Lumsden Road and above the general accident site were noted to be variable and included changes from down-slope to up-slope and from up-canyon to down-canyon. Gusts of wind were noted that came down-canyon and wrapped over the ridge dividing the west aspect of the accident site and the south aspect of Drew Creek.

Specific Fire Spread

A review of macro and micro burn indicators showed that the spread of the fire was primarily up-canyon and up-slope to the northeast. Backing and lateral burn indicators on the right flank (the flank closest to the general accident site) below the road show a slow, to moderately burning, fire spreading across and up-slope against an up-canyon wind and toward the accident site to the south. Occasional moderate up-slope runs of 10 to 20 feet and individual torching of low brush are evident where surface fuels and brush were mixed, continuous and the fire spread into the brush from below. These areas were small in size and scattered among the total burn area. No evidence of re-burning was observed.

Photo H-4. Area up-canyon of accident site looking north and up-slope showing the terrain and fuels where the fire was burning prior to entering the accident site. Accident site is out of photo to the right about 200 feet. Typical light surface fuels of short grass and leaves on poor soil site with rocks.

Macro burn indicators above the road, including degree of burn indicators, ash deposits and the relatively close alignment of the right flank above and below the road at the time of the accident indicate that the fire above the road moved up-slope and toward the south at a faster pace and burned hotter than below the road. This increased lateral spread indicates that fuel continuity and variations in the winds played a greater role in the spread of the fire above the road on the west aspect. This is consistent with wind conditions noted during the week and a half after the fire (see conditions section), smoke conditions noted during the final frames of the air attack video taken about 15 minutes prior to the accident and comments from the air attack expressing concern about the fire hooking below the retardant line on the right flank. Based on post-incident wind observations, this increased fire spread to the south would be expected to increase higher up on the slope.

Photo H-5. View of west slope showing heavy deposits of white ash above the road consistent with hotter burning and higher fuel loads in this area. Below the road only isolated small patches of white ash are present with the decrease even greater near and at the accident site.

Increased physical barriers such as rock outcrops and chimneys with sparse fuels also restricted fire spreading across the slope below the road. Burn indicators on the right flank below the road are consistent with restricted lateral spread due to topographic and geologic features. Lower on the slope, near the river, burn indicators show that the right flank of the fire was originally backing slowly in sparse grass and leaf surface fuels and into a light wind. As this lateral spread continued across the slope, burning debris rolled down-slope into the chutes formed by the rock formations below. In some cases evidence of large burning logs and limbs was observed to have rolled down-slope to the river area. Most of this rolling debris occurred after the fire front had moved through the area.

Photo H-6. View just up-canyon from accident site. View shows fuels and topography where fire was backing into wind toward accident site at right out of photo.

Burn indicators including cupping on low lying brush, protection indicators on and around rocks, degree of burn and leaf freeze showed that on the lower one quarter of the slope below the road, a slow burning backing fire continued to burn cross-slope towards the accident site. Burned fuels indicated that prior to reaching the general accident site the backing fire moved into a stand of low oak trees and brush with openings covered by more continuous leaf litter and pine needles. This increased continuity in fuels from sparse grass to leaf litter allowed the fire lower on the slope to continue its spread south.

Photo H-7. View from mid-slope, up-canyon of the fireline. This is the area into which Helitack Captain Winger and Firefighter Andahl ran before turning downhill. Ash remains show increased fuel loading in the area.

Reports from the members of Helitack Crew 404 indicate that they chose the line location at the general accident site to take advantage of a break in the brushy fuels. This is consistent with the ash and burned stem remains at the site that indicates a decrease in brushy fuels in this area. During examination of the accident site, several locations were found where the surface fuels had been protected by moving objects. In these locations, the surface fuels consisted of sparse grass and a thin layer of leaf debris.

Near the lower one-quarter of the slope and outside of the proposed line location but within the accident site, the remains of a moderate sized downed oak tree with three trunks was lying up and down the slope. Near the top of the line location on the fire side, the ground appeared to have moderate leaf litter fuels with some dead and down brush and tree branches. About 25 feet below the road and on the fire side of the line was a mature gray pine. Next to this gray pine, toward the fire side and slightly downhill, was a single toyon bush.

Photo H-8. View from road at top of line construction (black arrow) down-slope towards gray pine (red arrow) and toyon bush (yellow arrow) which are located at bottom edge of fired out area and at upper edge of brush patch which sustained fire run.

Below the toyon bush and gray pine and inside the proposed line location was a moderately heavy patch of mixed toyon and live oak brush which covered an area about 45 feet up and down the hill and 28 to 30 feet across the hillside. Below this brush patch the undergrowth turns to scattered live oak brush, toyon and oak trees with leaf litter and some downed limbs. Below this initial transition from the brush patch, the area opens up to patchy brush, oaks and leaf litter.

Photo H-9. View of lower end of brush patch showing beginning of run (red arrow) in brush up-slope. Constructed handline (yellow arrow) located in right lower corner.

Photo H-10. View of brush patch (red line) which burned off just inside line location directing convective heat towards the upper end of the line near the road.

Burn indicators show that the fire spread into this lower area of patchy brush, oak and leaf litter across the slope from the sparse grass and leaf fuels. This fire burned across the lower quarter of the slope and against the wind, starting from the sparse grass to the north and leading into the leaf litter and brush. Indications support the fire crew observations that the fire just below the road was within 10 feet of their proposed line location when they began their firing-out operation. Burn indicators show that in the area below the gray pine and toyon bush, unburned ground and brush fuels existed between the line location and the fire's edge for 30 feet or more prior to the accident.

At the same time the fire was spreading cross-slope below the road, fire had established itself above the road and spread into a standing snag about 80 feet tall. The snag was located about 30 feet to the north of the proposed line location, about 40 feet up-slope of the road. This snag was observed just prior to the accident by a member of Engine 43 to have been burning about 40 feet up.

Photo H-11. View of area above the road and above accident site. Green trees visible to the left edge of photo above road is area of possible helicopter water drops (blue line). In center of photo is area which burned hot (red line) and rapidly (spread direction shown in red arrows) prior to and during accident events. Burning snag (yellow arrow) was located below and to the left of bright green tree above road in lower left corner of photo.

The slope above the road and accident site was more open than below the road. The steep cut bank and initial fuels along the top edge of the cut bank restricted visibility from the road up-slope. Several members of the Helitack crew and crewmembers of Engine 43 confirmed this restricted visibility.

Photo H-12. View from south to north along Lumsden Road, above accident site, showing steepness of cut bank above road and area burned by spot fire (red line) on cut bank.

On the up-slope side of the road and toward the north, a line of low, burned fuels indicates the location of possible helicopter water drops made by Copter 404 (See Photo H-11, page 140). A number of burn patterns are present to indicate that a low-intensity fire burned cross-slope and through this area in several locations. Side-slope and to the south of this area the fire established itself in a pocket of heavy brush and surface fuels. The source of the spread of this fire could not be conclusively determined but strong evidence indicated it to be lateral spread across the slope from the north. A possible spot fire generated by a hot ember dropping from the burning snag nearby cannot be supported due to the distance and noted wind speeds but cannot be ruled out as a result of rotor wash.

Photo H-13. Area above the road in which the fire had established itself prior to accident events. Fire spread indicators show fire coming from right of photo and burning hot in upper right corner of photo before moving up-slope toward where photo is taken (red arrow). Spot fire from cut bank spread up-slope (yellow arrow) and joined this fire from lower left of photo.

Based on witness statements and supported by burn indicators, just seconds before the fire run and/or simultaneous to the fire run but not connected to it, a spot fire was observed at the base of the cut bank almost directly across the road from where the line location went downhill. These witness statements by Engine 43 Captain Tammy Mount and Firefighter Brian Austin indicate that the spot fire spread rapidly across the face of the cut bank and to the south, burning opposite the direction that the wind had been blowing up to this time. Statements by the two and burn indicators show that this spot fire turned up-slope about 30 feet south of its origin. Burn indicators show that this fire then spread in a narrow front, about 20 feet wide, up-slope where it joined the existing fire burning above the road.

Macro and micro burn indicators show that in the area above the road and to the north of where the spot fire had turned up-slope, an advancing fire front had already established itself from the fire that had burned cross-slope. This fire was extremely hot and spread in grass, leaf litter and brush over an area about one-quarter acre in size. Scorch heights on gray pines were observed to be 80 feet and higher along with consistent needle freeze above that level. Brush consumption in this area was more complete than in most other areas on the west aspect. Burn indicators in this area show that this fire was burning with a wind that was opposite the direction that the winds had been burning below the road prior to the fire run and with the slope in a southeasterly direction. The lateral spread of this fire was joined by the spot fire from the cut bank above the location where Captain Mount observed the spot fire to turn uphill. This fire spread from the west aspect above the road up-slope to the southeast towards the lower levels of the south slope in Drew Creek. Burn indicators show that this fire rounded the ridge dividing the west aspect above the accident site and the south aspect in Drew Creek and turned up-slope to the east.

Photo H-14. View from north to south along Lumsden Road above the accident site from next to the top of the line construction and near the reported location where the spot fire was located. Spot fire spread along slope (red arrows) away from camera and then turned up-slope.

Photo H-15. Gray pine located along dividing ridge between Drew Creek south aspect and accident site west aspect slopes. Needle freeze (black arrow) and scorch height on pines indicates severe burning activity and wind directions curling from the west aspect up-slope and east, turning up-slope and to the north on the south aspect. Photo taken looking generally west to east.

Photo H-16. Photo is taken near ridge separating west slope and north slope above the road and accident site. Photo shows route that fire traveled (red arrow) and the degree of burn.

Photo H-17. Photo taken from ridge above road and accident site, which separates the west slope and the south slope. View is up-slope with west slope to left and south slope to right. Photo shows path where fire turned up-slope/ridge (red arrows) and degree of burn. Pine tree in upper left corner shows needle freeze indicators of fire coming up-slope from this location towards it. Fuels changed in this location from leaf and needle litter with patches of brush to consistent chamise brush field to right of photo.

At the same time as the fire activity on the cut bank above the road, the fire below the road, which had been backing cross-slope and into the wind on the lower quarter of the slope, made a rapid run cross-slope to the south and up-slope. This fire spread directly toward the lower four members of the Helitack 404 crew. Burn indicators show that this fire spread remained initially in the surface fuels and moved rapidly under the brush present in scattered locations in this area.

Photo H-18. View from lower third of slope below the road at accident site looking from south to north cross-slope towards the direction where Helitack Captain Winger indicated the fire run had come from (red arrows). Chain saw work visible on right edge of photo and near center of photo (blue arrow).

The timing of the spot fire spread and fire spread below the road are simultaneous, or nearly so, as supported by witness statements of Captain Mount. Captain Mount stated that she saw an approximately one-foot diameter spot fire spread to the south, run along the side of the cut bank and spread for about 30 feet. Captain Mount stated that she jogged alongside this spreading fire for about 30 feet and then felt the wind to her back for the first time. She said that she turned and looked below the road and observed fire spreading up from the lower levels of the slope below the road while the spot fire above the road turned up-slope.

As the fire on the lower one-quarter of the slope below the road reached the bottom of the mixed brush patch of toyon and live oak approximately 28 feet inside the line location, burn indicators show that intensity, slope and fuel continuity (both surface and brush) provided enough heat to lift the fire into the brush itself. The consistent up-slope, and slightly to the south (right), burn pattern shows a rapid and hot torching run of this brush patch (45 feet up-slope) with most of the heat vectoring up-slope to the right and across the upper portions of the line construction where two members of the Helitack 404 crew were attempting to escape up-slope to the road.

Photo H-19. View from line location down-slope with brush patch visible to center and right of photo. Fire spread up-slope (red arrow) toward the location from which the photograph was taken and from the downhill right center of photo.

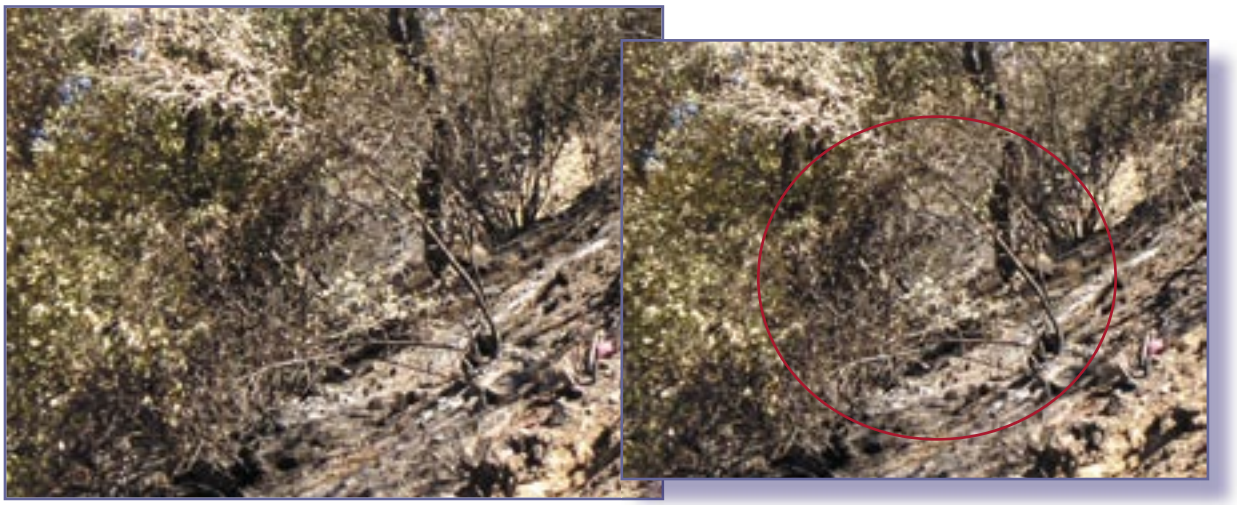

Photo H-20. View from mid-slope below road in accident scene looking from south to north cross-slope towards bottom of brush patch showing transition area (red circle) from surface fire to brush fuel fire.

As the left shoulder of this torching brush run reached the gray pine and single toyon bush up-slope of the brush patch and interfaced with the area fired-out and without surface fuels, the degree of burn indicators show the fire reduced in intensity leaving leaves unconsumed on the lower edge of the toyon bush. The right shoulder of the fire continued to the right of the gray pine, across the line and to the road above. Degree of burn indicators on the lower right heel of this run, near the lower line location, shows lateral spread of the fire consistent with beginnings of the run in the brush.

While the advancing fire moved through the brush patch just inside the line, burn indicators show that the lower flank continued to move cross-slope to the south and reached the leaf litter and cut brush from the line construction in that area. This fire then turned up-slope and, influenced by the primary run in the brush patch, continued up-slope on the other side of the line location. Burn indicators show that this narrow run on the other side of the line split about one-third of the way below the road with a narrow, advancing front turning to the south and an up-slope front joining the fire from the brush patch.

A large oak tree just below the road and about 30 feet across the slope from the line location (south) shows leaf freeze indicating substantial convective heat directly in this area where the two fire fronts have joined and reach the road. This location is also directly aligned with the location across the road on the cut bank where the spot fire had turned and rapidly spread up-slope. The fire front below the road subsided when it reached the road barrier and the already burned area across the road.

Photo H-21. View of oak tree with leaf freeze indicators (red arrow) showing fire spreading up-slope to road in accident site. Oak is located about 30 feet south of where line left road. Gray pine (yellow arrow) about 25 feet below top of constructed fire line is seen behind the oak tree.

Protection indicators located during the site examination indicate that the area where the victim's body was found, side-slope to the south of the lower line location and below the major rock outcrop, burned after the arrival of the body at that location. Burn indicators show a lateral fire of low to moderate intensity crossed this lower slope some time shortly after the advancing fire turned up-slope. The burning of the heavy downed oak tree in this area added to the intensity and long duration of heat in this area once it began to burn.

Photo H-22. Photo of fire shelter recovered about 14 feet up-slope from body recovery site. Unburned vegetation attached to and protected by underside of shelter indicates that this area had not burned at the time the shelter reached this location.

Photo H-23. Photo of unburned vegetation located under loose rock about 2.5 feet up-slope from body recovery site, indicating that this area was not burned at time rock slid to this location.

Burn indicators, including degree of burn, cupping and protection indicators, show that about 40 feet across the slope to the south from the line location the fire transitioned into a backing fire again with low rate of spread and intensity. The fire was contained later at that location.

On-Site Interviews

During the final days of on-site investigations, two members of Helitack Crew 404 were taken to the accident site and interviewed. During that interview, I took part and spoke with both Helitack Captain Jonah Winger and Firefighter Jeff Boatman.

Captain Winger and I also climbed down to the top of the major rock outcrop where the line location had gone through it. Captain Winger told me he had gone to this location when he scouted the proposed line route. Captain Winger pointed out to me the location down-slope and to the right where he said the flaming front came from. This area was consistent with the burn indicators I had already found and consistent with fire spread into the bottom of the brush patch just inside the line near where we were standing.

Captain Winger described for me the fire behavior he saw when the fire spread across and up-slope towards him and his crew. He stated that the fire "crowned" below him while it spread in his direction. I observed and commented to Captain Winger that there were no burn indicators that suggested or supported a "crown" fire in that location. Captain Winger agreed. I then asked him if what he termed a "crown" fire could have been the torching of cut brush from the line construction and he stated that it could have been.

Captain Winger told me that when he saw the fire below him he shouted the alarm and then ran into the flaming front in an attempt to reach the interior of the burn where it was cooler. He stated that after running about 20 feet into the burn through burning brush, he was still getting burned and he turned down-slope in an effort to reach the river below. When I asked Captain Winger how he had run through 20 feet of fire with the brush burning, which I found inconsistent with the reported damage to his Nomex, he told me that there was only scattered brush burning where he had run.

Captain Winger told me that at some time during his escape through the flames, he crossed paths with Firefighter Agustin who was headed down-slope. He also told me that immediately after he shouted the alarm, he saw the two-person saw team escape down-slope and to the left (south).

I asked Captain Winger if he knew that Firefighter Schicke wore a knee brace. He told me that about one month prior, he had noticed her doing her physical fitness with a knee brace on. Captain Winger stated that he asked Firefighter Schicke if her knee was bothering her and she answered "yes." Captain Winger stated that he had also heard about Firefighter Schicke going to a medical examination some time in the past, which he thought was associated with her knee. Captain Winger did not know if she had a brace on the day of the accident.

I spoke with Firefighter Boatman who told me that he had originally scouted the road to the north when the crew first arrived because he was familiar with the area. He said that when he returned, he went down the line with Firefighters Schicke and Neveau. He told me that he had given instructions for the crew below the rock outcrop to cut back to the north, towards the fire, so that rocks loosened by the other crew members would not roll down on them. He said that at one point instructions were passed to get a back pump and he went back up the slope to get one.

Firefighter Boatman stated that the burning-out operation was going well, with low-intensity fire burning back towards the fire's edge about 10 feet away. He said at one point he noticed the flames "waver" and turn back towards the line. Firefighter Boatman said that immediately after that the fire activity below took off. Firefighter Boatman stated that he looked down the hill and saw the fire coming up from below. He said that he shouted, "get out of there" to the crewmembers below the road. He said that he could see Firefighters Schicke and Neveau.

Firefighter Boatman said that he retreated to the south along the road to near the bend in the road. He said that he turned back and saw Firefighter Neveau on the road just above the line location and that the worst of the fire coming up the hill was also in that same area. Firefighter Boatman made no mention of the spot fire on the cut bank.

The next day an on-site interview was conducted with the supervisor of Engine 43, Captain Mount. Captain Mount told us that when she got the instructions to go down into the canyon she was concerned and that she asked the IC if he was sure he wanted her engine to go down into the canyon. She proceeded with her engine down into the canyon and met with the IC near the Lumsden campground. She said her engine continued towards the fire where she had a conversation with the IC. She had her engine stop short of the right flank where the road crossed Drew Creek.

Captain Mount stated that she walked along the road with Firefighter Austin towards the right flank in an effort to determine if it was safe to proceed with her engine and to make a face-to-face contact with the captain of the helitack crew. Captain Mount said that when she rounded the corner and could see the right flank, she saw one firefighter on the road that she later identified as Firefighter Boatman. She stated that they walked up to Firefighter Boatman and as they began a conversation, she noticed a spot fire about one foot in diameter at the base of the cut bank across from the line location.

Captain Mount said that the spot fire spread too rapidly for them to do anything about it. She stated that as she began to "trot" to the south along the road, she was just keeping up with the side slope spread on the cut bank. She stated that after about 30 feet the spot fire turned and ran up-slope. Captain Mount said that it was then that she first felt the wind change at her back as she ran away. Captain Mount told us that it was about then that she looked over the downhill side of the road and saw fire spreading up from below.

Captain Mount stated that she yelled at her firefighter to follow her and that after some hesitation he did so. She said that the two of them then took Firefighter Boatman to the engine. Captain Mount said that when she returned, she ordered her engine to turn around to prepare to leave the area if need be.

On Tuesday, September 21, 2004 I met with Firefighter Austin near the fire site. He told me that on the day of the accident he had walked from the engine to the right flank with Captain Mount. He said that when they approached they saw one firefighter on the road that he determined to be Firefighter Boatman.

Firefighter Austin volunteered that when he approached he did not see any fusee, smell a fusee, or see any slag. He explained that he thought the spot on the cut bank was from the burning taking place just below the road and next to the line. He stated that he did not see an ember land there but did observe smoke drifting across the road from that location.

Firefighter Austin said that prior to the spot fire taking off, he noticed a burning snag above the road and just inside the right flank of the fire. He showed me the stump of the tree that had been cut down since. Firefighter Austin estimated that the snag had been burning about 40 feet up.

Physical Evidence

On September 16, 2004 I began the identification, documentation and collection of physical evidence on the accident site. I was assisted by retired CDF Investigator Chuck Lawshe. During the collection of the items I took photographs of the items as they lay on the ground, and in some cases during the collection process, to document the damage to each.

During the collection of the physical evidence, several observations were made. Most of the debris believed to be associated with Firefighter Eva Schicke was located along a debris channel formed by the natural slope of the hill towards a shallow chimney running up and down the accident site. This debris channel began at the top of the line location and followed it down to the mid-slope rock outcrop. At this location, the line turned to the right and the debris channel veered to the left, over a drop-off formed by the rock outcrop and down-slope near the final right flank.

Debris collected on the hillside consisted of burnt Nomex cloth remains, melted plastic, fire shelter remains, web gear remains and aluminum food packets as well as unidentified manmade objects. The items found highest on the slope, believed to be associated with Firefighter Schicke, were on the line construction about 23 feet from the road. These items were a burnt segment of cloth and melted plastic around a 12" long oak limb, which was lying on the ground. These items were near the top of the debris channel.

Photo H-24. Burned debris associated with Firefighter Schicke highest on slope located in lower left corner of photo (blue arrow). Road (red arrow) shown 23 feet above at end of dirt slope.

Additional associated aluminum fragments and remains thought to be those of food packets were located along the line below 23 feet from the road but above the rock outcrop in and along the edges of the debris channel. At the point where the line cut to the right and the debris channel continued down-slope and to the left, at the top of the rock outcrop, plastic remains were found on the right side of the line in a cluster of cut brush stobs. This melted plastic appeared to be the remains of a standard issue wildland firefighter one-quart canteen. This debris was located to the north side of the debris channel.

Up-slope about 8 feet from the plastic and to the north of the line about 6 feet was located the remains of what could be a chinstrap and assembly for a hard hat. This was the item located furthest inside the fire line and out of the debris channel.

At the base of the rock outcrop along the debris channel I located the remains of a forest fire shelter. This item was partially buried by dirt debris, which had slid down-slope in the debris channel. During recovery of this item it was noted that the ground under and protected by the fire shelter had unburned and partially burned leaf litter. Additional unburned leaf litter was located attached to the underside of the shelter itself. In addition to the aluminum shelter, a fire shelter case snap and cloth remnants were located. These remains were located about 14 feet up-slope of the final body recovery site. (See Photo H-22, page 147.)

At about the same level on the slope, across the slope to the south about 12 feet was located a small particle of melted metal that could not be identified. This was the item found furthest to the south outside the debris channel.

At the body recovery site I collected numerous particles of burned Nomex cloth, web gear utility clips, aluminum fragments, boot eyelets and hooks. Under one of the larger burned Nomex fragments I observed partially burned leaf and grass, debris that had been protected by the Nomex. About 2 feet above the body recovery site I observed burn indicators on and around a loose rock and an embedded rock above it which indicated that the body had lodged at that location and burned for some time prior to sliding to the recovery location. Once the loose rock was turned over and removed it was observed that the ground below it was covered with unburned leaf and grass debris along with partially burned vegetative debris around the edge of the rock

Photo H-25. Body recovery site (pink flags) below rock outcrop and side slope from heavy fuels.

Photo H-26. Body recovery site (pink flags) from line location at rock outcrop looking down and side slope. Fire shelter recovered near center left edge of photo.

Photo H-27. View up-slope and from line location showing rock outcrop, located above body recovery site that line passed over.

Along the road itself we recovered five back pumps with various degrees of burning and five "Rhyno" tools. One of these tools was modified with a "Combie" tool head on it. This tool was the only tool with evidence of high heat damage to the handle. This tool is believed to have belonged to Firefighter Schicke. One other tool handle had several burn spots on it.

Conclusions

Physical burn indicators support the spread of a backing fire towards the accident site from the up-canyon direction. Evidence of sparse grassy fuels near the lower slope along with a gentle up-canyon wind restricted the lateral and backing spread of the fire initially towards the site.

Fire above the road to the north of the accident site burned in more consistent fuels and under shifting wind directions, allowing it to progress to the south at a faster pace than below the road. This is supported by post-accident wind observations above and below the road as stated in this report and by the greater degree of burn indicators above the road than below it. It is also supported by the witness statements, which put the two fire segments of the right flank nearly even at the road at the time of the accident.

Burn indicators, as discussed in this report, support the fact that the fire above the road established itself above the accident site independently of the fire below the road and independently of the spot fire on the cut bank. Degree of burn indicators, needle freeze and ash residue show that this fire above the road and accident site burned hotter in a concentrated area than seen anywhere else near the accident site. This burn activity spread quickly to the southeast and onto the chamise covered south-facing slope of Drew Creek where it turned up-slope again and made a significant run to the upper ridgeline.

Segments of the last moments of the air attack video, statements from the at scene air tanker pilot and physical burn indicators on the ground above the road, show that wind direction above the road was shifting and being drawn to the northeast prior to the accident.

Post-accident wind observations do not identify any wind pattern below the road which would duplicate the wind reversal as experienced at the time of the accident. The burn events above the road, including the intensity, fuel changes and wind shifts noted during post-accident observations support a finding that the wind and fire below the road at the accident site was directly influenced for a short period of time by the intense fire run which occurred above the road. The physical evidence supports a drawing of the fire below the road and the spot fire on the cut bank, indeed the entire lower right flank towards and into the fire making a substantial run above the road.

Physical evidence supports the fact that at the time of the accident, as much as 30 feet of unburned fuel existed between the line location where Firefighter Schicke stood and the fire's edge. This is supported by the fact that the fire climbed into the toyon brush next to the line at that location but could not sustain its run in the brush when it reached the area already burned out by the firing operation, as witnessed by the leaves remaining on the brush at that location. Lateral burn indicators may sustain an even wider distance in that area.

This is further supported by statements made by Captain Winger who stated that he turned and ran into the oncoming fire for about 20 feet before he realized it was too hot and he turned downhill. Under the pre-accident descriptions of fire behavior given by Captain Winger and other members of the crew, one-foot flame lengths backing into the wind, residual flame fronts should have been narrow and short lived. His description of at least 20 feet of depth of hot and intense burning fire indicates a recent spread of fire over that entire distance plus any distance he ran prior to entering the flaming front.

Physical burn indicators on the ground show that the fire that spread into the bottom of the brush patch came from this fire front Captain Winger described and first transitioned from the ground to the brush fuels 28 feet from the nearest line construction evidence.

Physical evidence associated to Firefighter Schicke support the fact that she progressed during the fire run to at least within 23 feet of the road and probably further. No evidence was located which would not support the claim by a fellow firefighter that she was last seen within 5 feet of the road. Physical evidence associated with Firefighter Schicke recovered along the debris chute indicates that above 23 feet from the road, her equipment was degrading to the point that segments of her Nomex uniform were coming off. This indicates that Firefighter Schicke was exposed to the fire front which burned through the brush patch, down-slope from this location and just within the line. Burn indicators show that additional heat sources contacted the body from the cut brush outside the line and surface fuels that were burning.

Evidence of unburned vegetation under the fire shelter, a rock which slid down the debris chute and under the body of Firefighter Schicke support the fact that at the time her body reached the recovery site, that location had not yet fully burned. This would indicate that her body reached that location within a short period.

While the position of her body on its back with legs bent may suggest to some that she was still alive at the recovery site, this is not supported by the fact that the area was not burned, the fact that she was within the debris chute (indicating a slide of the body from higher up) and finally the presence of body remains higher on the slope above the final recovery area prove that she was dead prior to arriving at the final body recovery site.

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